EXHIBIT II

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ANALYSIS OF POTENTIAL INTERFERENCE

FROM

AUTOMATED MARITIME TELECOMMUNICATIONS SERVICE

TO

NTSC TV RECEIVERS

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ANALYSIS OF POTENTIAL INTERFERENCE FROM AUTOMATED MARITIME TELECOMMUNICATIONS SERVICE TO NTSC TV RECEIVERS

SUMMARY:

The mathematical formulation in FCC/OST TM82-5 for determining the potential interference between AMTS and NTSC TV receivers has been evaluated and confirmed to be valid. However since its development in 1982, technology has improved and new information has been developed so that it can be shown that the predictions made using the parameters developed in 1982 are conservative by 20 dB or more (a power ratio of 100 to 1 or greater).

It is known that the R-6602 prediction method yields too much coverage for the TV stations. This has been recognized by the FCC and the Broadcasters, so an improved propagation prediction program using Longley Rice methodology was developed during the recent DTV proceedings which has the potential for significantly improving coverage computations. The increasing penetration of cable TV delivery has significant potential to reduce the risk of interference to TV reception. The minimum acceptable D/U for NTSC receivers should be updated because of improvements in TV receivers, and values for DTV receivers which are less susceptible, have been established. The quantification of these improvements have been addressed elsewhere.

The parameters in the model that have received attention since 1982, and are included in the 20 dB of conservatism above are as follows. The temporal variation parameter and antenna polarization discrimination values were obtained from ITU-R PN.370-7. The temporal correlation coefficient appropriate for each situation has been recognized in the computation of interference contours. And finally, because of the implementation of DTV rules, the existing parameters for the TV station height and power should be used instead of the FCC maximum permissible values in predicting interference potential.

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1. INTRODUCTION:

The rules for operation of AMTS (Automated Maritime Telecommunications Service, formerly Inland Waterways Communications Systems) were set forth by the FCC in General Docket 80-1.[1] The method for evaluating the potential for interference from transmitters of these systems into TV receivers on adjacent frequency assignments was subsequently set forth by the FCC/OST in 1982[2]. The purpose of this analysis is to provide an updated evaluation of the interference potential for these systems. It has been funded by Regionet Wireless, but the technical results of the analysis have been independently derived, and have not been influenced in any way by Regionet.

AMTS occupies frequencies in the band 216-220 MHz while TV channel 13 is located immediately below from 210 – 216 MHz. Since these frequencies are immediately adjacent to each other, the ability to filter the potential interference is limited.[3] TV channel 10 on 192-198 MHz also has the potential for interference from AMTS because of the "half IF beat" effect due to the second harmonics of the TV local oscillator and interference signals. It is easier to filter these frequencies, but the potential for interference at this band is also present. The propagation path attenuation and antenna coupling between the AMTS transmitter and TV receiver is therefore of paramount importance. Additional information regarding these parameters has been developed since 1982, and will be presented herein.

2. PROPAGATION PREDICTION

The propagation path loss curves described in FCC Report R-6602[4] were used for interference prediction in TM82-5 because "These curves are acceptable standards for determining the potential for interference between TV services, making them very appropriate for the present related application." The loss is a function of the distance, between the transmitting and receiving antennas and their height. It is also statistically a function of time and the receiver local terrain height variation. The temporal signal

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[1] FCC 81-24 General Docket No. 80-1, RM-3101, RM-3128, RM-3129, Report and Order in the Matter of Amendment of parts 2, 81 and 83 of the Commission's Rules to Allocate Spectrum for an Automated Inland Waterways Communications System (IWCS) along the Mississippi River and Connecting Waterways and, Maritime Mobile Radio Services: Improvement in Service Through Provision for Automated VHF Common Carrier Systems and, VHF Frequency Assignments to The Maritime Radio Services In the New Orleans and Lower Mississippi Rivers Areas and on the coastlines of the contiguous states, adopted January 29, 1981, released March 11, 1981.

[2] R. Eckert, OST Technical Memorandum, Guidance for Evaluating the Potential for Interference to TV from Stations of Inland Waterways Communications Systems, FCC/OST TM82-5, July 1982.

[3] Some improvements in receiver performance have been made as documented in the FCC proceedings that have recently resulted in the Digital TV allocations, but the effect of these improvements will not be pursued in this analysis.

[4] Jack Damelin, Willam A. Daniel, Harry Fine, & George V. Waldo, Development of VHF and UHF Propagation Curves for TV and FM Broadcasting., FCC Report R-6602, Third Printing May 1974.

variation is assumed log normally distributed. Its standard deviation is a function of transmitter height and the distance between transmitter and receiver with a maximum of about 8.4 dB. The standard deviation of the terrain variation is a constant 8.6 dB.

In general, it has been found that the R-6602 curves predict more coverage for the TV signal than is found in practice. Therefore, the FCC has moved away from their use to the Longley-Rice propagation model. They stated in a recent R&O that "OET Bulletin No. 69 provides guidance on the implementation and use of the Longley-Rice methodology for evaluating DTV and NTSC coverage and interference."[5] Since a similar statement was made about the use of R-6602 for AMTS to TV interference prediction, it is most appropriate that the improved methodology in Bulletin 69[6] be considered for adoption to determine potential interference of AMTS going forward.

3. TEMPORAL SIGNAL VARIATION

It is stated in TM82-5 that the temporal variation in the signals from the TV transmitter and AMTS at the TV receiver are un-correlated. However, in the proceedings on DTV, the subject of correlation between two signals at a TV receiver has been revisited by the Commission. In the R&O above[7] it is stated:

> The estimates contained in the DTV Table are based on the assumption that the interfering and desired signals are not correlated when it comes to signal fading. That is, the methodology assumes that the desired signal is at its weakest or minimum level and the undesired signal is at its strongest or maximum level at any particular point.[67] At the edge of the station's service area, this results in very large differences in desired and undesired signal levels. In practice, however, adjacent channel signals from co-located or closely-located sources tend to be highly correlated since the signals travel over the same or nearly the same path and are affected by the same propagation and weather conditions. In these instances, the signals tend to exhibit the same fading characteristics and large differences due to propagation factors do not occur. Recent studies by our laboratory confirm this correlation. We therefore believe that a more accurate modeling of service coverage and interference would take this correlation into account and that the service coverage and interference for many adjacent channel situations will be better in practice than the estimates shown for the DTV Table.

[5] FCC 98-24, MM Docket No. 87-268, MEMORANDUM OPINION AND ORDER ON RECONSIDERATION OF THE SIXTH REPORT AND ORDER, In the Matter of Advanced Television Systems and Their Impact upon the Existing Television Broadcast Service, Adopted: February 17, 1998 ; Released: February 23, 1998, par. 8 pp. 6

[6] FCC OET Bulletin 69, Longley-Rice Methodology for Evaluating TV Coverage and Interference, July 2, 1997, obtainable from the FCC web site at: http://www.fcc.gov/Bureaus/Engineering_Technology.

[7] See reference in footnote 5 par. 93, pp. 39.

On line 5 of the quotation above, there is reference to footnote 67. Footnote 67 explains that:

> 67 The methodology assumes a value for the desired signal that occurs at 50% of the locations for 90% of the time, and a value for the undesired signal that occurs at 50% of the locations for 10% of the time.

The "studies by our laboratory" were started in late 1997 and continued into 1998 and 1999.[8] They involved long term simultaneous measurements of received signals from multiple stations separated 20 to 30 miles or more. As defined, the correlation coefficient, ρ, between the signals from two stations can vary from 1.0 (perfect correlation) to 0.0 (un-correlated) to –1.0 (anti-correlated). The FCC measurements show that ρ between the stations studied is regularly 0.8 to 0.9 and higher. The FCC measurements have been replicated in a study by others.[9] Though these studies were done at UHF, there is no evidence that they will not apply to high band VHF.

The effect of this correlation is to increase the median AMTS signal allowed at a TV receiver and still maintain acceptable performance. The temporal factor, expressed in dB, is defined as R(T) where T is the percent time. With subscripts of t for total, d for desired signal and u for undesired signal, $R_t(T)$, used in the FCC analysis was:

$$R_t(T) = [R_d^2(T) + R_u^2(T)]^{1/2}$$

When the correlation coefficient is included in the analysis, the temporal factor becomes:

$$R_t(T) = [R_d^2(T) + R_u^2(T) - 2\rho R_d(T) R_u(T)]^{1/2}$$

As an example, using the R-6602 curves, at the grade B contour of 76 miles, $R_d(T)$ from a TV transmitter HAAT of 1000 feet is about 9.1 dB. With an AMTS transmitter at a HAAT of 200 feet and 40 miles from the same location, $R_u(T)$ is about 6.5 dB Using the approach of TM82-5, the temporal factor is 11.2 dB. With a correlation coefficient of 0.8 the temporal factor is only 5.5 dB, a reduction of 5.7 dB.

In addition, the values of R(T) that are used in TM82-5 are higher than values used in other internationally recognized standards. The International Telecommunication Union (ITU) has published propagation curves that are used for TV Broadcasting,[10] and the difference between those F(50,10) and F(50,50) field strength curves yield values for R(T) that are shown in Figure 1. These values apply to transmissions over land.

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[8] Phone conversation with Bob Eckert of the FCC/OET March 4, 1999.

[9] Allen Davidson, Initial Report on Long Term UHF Propagation Measurements, Motorola Technical Report 98-01, May, 1998.

[10] Recommendation ITU-R PN.370-6, VHF and UHF Propagation Curves for the frequency Range From 30 MHz to 1000 MHz, 1994 PN Series Volume, pp. 253-284

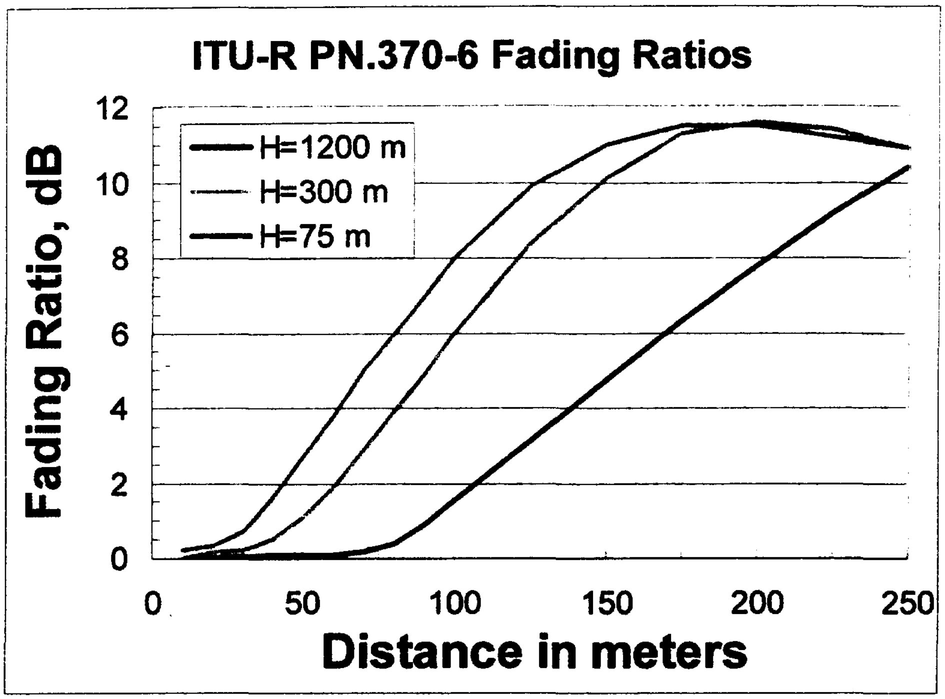

Figure 1 Fading ratios vs. distance from transmitter from ITU-R PN.370-6

Using the same values as the example above, R_d (T) for the TV transmitter is 7.6 dB and for the AMTS transmitter is about 4.4 dB. The temporal factors with the correlation coefficient is 4.8 dB. We see that the temporal factor goes from 11.2 dB to 4.8 dB, a total reduction of 6.4 dB by applying these two temporal corrections to the computation. This result is an example for a specific case. It is estimated that a reduction of up to 8 dB in the computed ratio of desired to undesired signals would result from appropriate application of these two corrections in specific cases.

4. POLARIZATION PROTECTION

In TM82-5 the protection offered by the difference in polarization between the TV and AMTS signals was ignored because it was considered "greatly dependent on the relative bearings of the signal sources" as reported in a study done at the National Bureau of Standards. This has also been addressed by the (ITU).[11] They state that:

> ...between 30 and 300 MHz, the median value of discrimination that can be achieved at domestic receiving sites by the use of orthogonal

[11] ITU-R Recommendation 419-3, Directivity and Polarization Discrimination of Antennas in the Reception of Television Broadcasting, 1994 BT Series Volume, pp. 246-248.

> polarization may be as much as 18 dB, and under these conditions, the values exceeded at 90% and 10% of the receiving sites are about 10 dB and 25 dB respectively.
>
> The values of discrimination are likely to be better in open country and worse in built up areas or places where the receiving antenna is surrounded by obstacles. For domestic installations in densely populated districts, the median values of 18 dB will usually be realized only at roof level; and this value may be reduced to 13 dB or less at street level.

The contradictory statements can be resolved when it is recognized that the polarization of side and back-lobes is primarily random. Thus the polarization is "greatly dependent on the relative bearings of the signal sources". On the main beam, however, the polarization purity of the antenna is preserved and where the antennas are located on the rooftops (such as near the Grade B contour) of the suburbs, the 18 dB median is quite appropriate. Therefore, it is not appropriate to use the factor for polarization discrimination and add to it the front to back/side ratio. If the AMTS station is in the rear of the receiving location compared to the direction of the channel 10 and 13 TV stations, only the least protection factor should be used. If the AMTS station is in the main beam, it is appropriate to use polarization discrimination as described by ITU.

Subsequent to TM82-5, further support has been given by the FCC to the inclusion of polarization discrimination in interference computations. Regarding cross polarization protection into TV channels 4 and 5, Bulletin 67[12] issued in 1988 states:

> It has generally been found that, on average, outdoor TV antennas exhibit about 10 dB cross polarization discrimination. The model includes 0 dB cross polarization discrimination for distances within the Principal Community contour of a TV station and 10 dB cross polarization discrimination for distances beyond the Grade A contour on the assumption that a majority of households beyond this contour will use outdoor antennas.

It is recommended herein that 18 dB of interference suppression be used at private residences as described by the ITU, but only outside the Grade A contour and for a combination of cross polarization protection and antenna directivity. It is important to note that cable TV headends use commercial quality directional antennas which are of a superior quality to the household antennas described above. They are directional with excellent polarization purity and are customized to provide rejection of interference while optimizing the desired TV signal. It is likely that residences that rely on cable delivery of the TV signal would receive further benefit from the cross polarization and antenna directivity than that quantified above.

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[12] FCC/OET Bulletin 67, Potential Interference from Operational Fixed Stations in the 72-76 MHz Band to Television Channels 4 and 5, March 1988

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5. OVERALL MODEL EVALUATION

The modeling approach used in OST TM82-5 involves computing the desired TV to undesired ATMS signal ratio (D/U) at the TV receiver. A required value of D/U, called "A" in TM82-5, is established which is the level at which just perceptible interference is visible. Both signals are a function of time and space, however, they can be handled separately. There are median (or average) values that are used to describe the signals without variation, and then the spatial and temporal factors are applied separately. All these quantities have been expressed in dB, so the parameters can be added and subtracted to obtain the result. Equation (1) in TM82-5 can be rearranged and put in the form:

$$D/U = P_d + F_d\,(50,50) - P_u - F_u\,(50,50) - [R_d^2\,(T) + R_u^2\,(T)\,]^{1/2} + R(L,G)$$

Where:

- P_d .... is the ERP (expressed in dBk) of the TV transmitter in the direction of the TV receiver.
- F_d (50,50) .. is the field strength in dBμ from the FCC R-6602 curves for a one kW ERP TV transmitter at the distance of the TV receiver.
- P_u .... is the ERP (expressed in dBk) of the AMTS transmitter in the direction of the TV receiver.
- F_u (50,50) .. is the field strength in dBμ from the FCC R-6602 curves for a one kW ERP AMTS transmitter at the distance of the TV receiver.
- R_d^2 (T) ...... is the 10% temporal fading ratio of the TV signal from Figure 10 of R-6602.
- R_u^2 (T) ...... is the 10% temporal fading ratio of the AMTS signal from Figure 10 of R-6602.
- R(L,G) ...... is a factor to take into account the spatial variation of the TV signal and the AMTS signal at the receiver. The value of R(L,G) is the amount in dB by which the D/U is higher than its median value.
- L .... is the percent of locations where AMTS performance is acceptable because either 1) the TV signal is too weak to provide acceptable reception, or 2) the D/U is greater than the value required to avoid interference.
- G .... is F_d (50,50) + P_d - F_s.[13] This is the amount by which the median TV field strength exceeds the level necessary for acceptable performance at the TV receiver.
- F_s .... is the minimum field strength, in dBμ, for acceptable service. The value at the Grade B contour is appropriate.

In words, this equation says that the desired to undesired signal ratio is equal to the field strength of the TV transmitter, minus the field strength of the AMTS transmitter, minus a

[13] There is a typographical error in TM82-5 on pp. 6 and in Figure 2 on pp. 9. The term + P_d is omitted from the expression for G. It is correctly presented in Appendix C on pp. C-2.

factor due to the temporal peaking of the signal strengths, plus a factor due to the spatial variation in the signal strengths. The powers and field strengths are obvious parameters in an equation for D/U, they follow from the definition. The individual temporal fading factors, R(T) are the standard deviation of the faded signal multiplied by 1.282 to get the cumulative peaking/fading level at the 10% probability point. And the composite fading factor for the TV and AMTS signals is found by taking the square root of the sum of the squares of the individual factors which is a standard technique for combining two independent random variables.

The spatial variation is more complex because it involves taking into account bounds where the TV signal does not meet a specified minimum (outside the Grade B contour). The derivation in Appendix C of TM82-5 starts from first principals and derives the cumulative probability that the D/U at the TV receiver is greater than the level R(L,G) at L percent of the locations where the TV signal, S_d (50,50) is greater than G + F_s. This relation is not expressible in closed form, so a computer program was used by the FCC to evaluate the expression for many data points.

Curves of constant G were drawn through the data points with L as the horizontal axis (the abscissa) and R(L,G) on the vertical axis (the ordinate). It is assumed herein that the programming was correct, and that the curves drawn in Figure 1 of TM82-5 are correct. One check was made with an analytical expression. Where the Grade B contour is far from the point under consideration (large G), a closed form expression in terms of erf(x), the error function, is possible.[14] This was used to check Figure 1 for large G, and it is correctly shown as a straight line with standard deviation (slope) of 12.16 dB and a value of R(L,G) = 0 dB at the point where L = 50%. of the locations.

Because it appears reasonable, and is based on historical precedence, the geographical contour of interest in TM82-5 is defined as the Grade B contour (the TV signal is adequate here) and any contour within it where:

> ... at more than 10% of the locations on the contour: (1) The desired TV signal by itself would be adequate at least 90% of the time, but (2) the ratio between desired and undesired fields is unacceptable more than 10% of the time.

So, from the curves of Figure 1, the value of R(L,G) is obtained by reading values at L = 10% for various intersections of the constant G lines and its negative is plotted in Figure 2 of TM82-5. The problem becomes finding that contour where these values apply for any proposed AMTS station.

The mathematics in the model appear to be done in a competent manner. No mistakes in setting up the methodology have been found. The stated parameters in TM82-5 which

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[14] and is given in equation (2.43) of the book: Handbook of Land-Mobile Radio System Coverage by Garry C. Hess, Artech House Publishers, 1998, pp. 27.

must be used in finding the contour are the **maximum permissible power** and height for full service TV stations and the **actual power** and height for low power and translator TV stations. The recent action by the FCC in regard to DTV gives cause to consider a change in the maximum permissible power requirement.

When the Commission allocated an additional TV channel for each full service station to use for DTV, they set a target date for turning off the NTSC stations. That date is 2006, subject to DTV being accepted by the viewing public.[15] In addition, should the Broadcaster choose to convert the NTSC channel to DTV, the existing contour is the limit to coverage that was the basis for the new allotment tables. Thus, it does not seem to be in the best interest of the Broadcaster to make major changes to the NTSC facilities when they will become obsolete in a very few years. So, it is not useful to protect the NTSC TV facility to the maximum power and height permissible, when the station is presently functioning with lower values and with little probability of change. And the difference can make a substantial difference in the computation of potential interference.

By actual count, the HAAT of 3 of the 4 channel 10 & 13 TV transmitters in the state of California in the Commission's TV data base are below 2000 feet. For instance, KGTV channel 10 in San Diego radiates the maximum power permissible, but the HAAT is only 750 feet compared to the 2000 feet permissible. The computed Grade B contour of 56 dBμ, using the R-6602 curves and 750 feet is 64 miles, but at 2000 feet it is 76 miles. The difference of 12 miles (6.5 dB) can be a significant factor in the design of interference mitigation for proposed AMTS systems for the area.

In addition, in TM82-5 the values of A, the required D/U values which produce just perceptible interference on a receiver for the two TV channels 10 and 13 were established in 1975. There have been improvements in the design and manufacturing of TV receivers which result in significant reduction of that value. Quantification of that parameter with newer NTSC TV receivers is left to others. Newer receivers that are just reaching the market will be designed to handle the new DTV signals, and there are DTV assignments of stations to channels 10 and 13.

In making the DTV channel assignments, the planning factors used by the FCC for susceptibility to upper adjacent channel interference on the new DTV receivers by either NTSC or DTV signals was reduced 25dB or more from that used for NTSC receivers.[16] In other words, DTV receivers are less susceptible to interference by 25 dB or more than NTSC receivers. We note that multiple AMTS signals on different AMTS channels produce a noise like composite signal that is similar in that respect to DTV signals. Therefore, this 25 dB reduction, appropriately applied, should become the standard D/U = A for AMTS into DTV receivers.

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[15] FCC 98-315, MM Docket No. 87-268, SECOND MEMORANDUM OPINION AND ORDER ON RECONSIDERATION OF THE FIFTH AND SIXTH REPORT AND ORDERS, In the Matter of Advanced Television Systems and Their Impact upon the Existing Television Broadcast Service, Adopted: November 24, 1998 ; Released: December 18, 1998, paragraph 3.

[16] See table 5A in the reference in footnote 4.

Finally, the number of households which receive their TV signal from cable is increasing every year. For the computation of potential interference, TM82-5 states: "Locations where the desired field is too weak for reception are counted as having no interference regardless of how strong the undesired signal may be."[17] If the TV receiver is attached to the cable, the desired field outside the cable will be too weak for direct reception. The quality of headend receiving antennas was discussed previously. Therefore, in considering the impact on the households within the contour of potential interference, the effect of cable TV reception should also be considered.

6. CONCLUSION

The prediction of potential interference of ATMS into TV receivers on channels 10 and 13 as described in FCC/OST TM82-5 has been evaluated. The mathematical procedure for determining the potential interference is valid. However, there are several parameters that go into the computation that have changed over time, and these can have significant impact on the area within the interference contour. Those identified herein and a recommendation are:

1. The propagation prediction curves of R-6602 predict too much TV coverage, and have been improved upon by new technology. The Longley-Rice methodology provides a more realistic interference contour for which protection should be designed.

2. The temporal variation R(T) used to predict the TV and ATMS signals is too high. In addition, there is correlation between the signals that was not taken into account. The value obtained from the broadcast propagation curves of the ITU-R.370-7 should be used, and the correlation coefficient, with appropriate values, should be included in the prediction method. It is estimated that up to 8 dB of unrecognized margin against the undesired signal is now provided from this source.

3. There is a difference in the polarization of the TV and AMTS signals that was not included in the interference prediction method. The directivity of TV receiving antennas outside the Grade A contour was also not included in the TM82-5 interference prediction method. The values in ITU-R.370-7 should be adopted. 18 dB of unrecognized margin is presently contained in these parameters.

4. In order to permit the TV station to increase their facilities to the maximum permissible, the computation of the interference contour is made with the FCC power and height maximums. Since the NTSC stations are being phased out soon, and the existing contour was used by the Commission to establish the contour for the new allotment plan, existing parameters should be used for AMTS interference

[17] See reference in footnote 2 pp. c2.

prediction. The HAAT of 3 of the 4 channel 10 & 13 TV transmitters in California is below 2000 feet. The unrecognized margin here varies with the particular TV transmitter installation; 6.5 dB is shown as an example.

5. Going forward, new values of A, the required value of D/U for NTSC receivers should be adopted. In the DTV proceedings, the commission has accepted values for DTV receivers that are 25 dB lower than for NTSC, and that factor should be applied to A for AMTS into DTV receivers.

6. There are many households that receive their TV signals on cable. They frequently can not receive the signal directly over the air. These should be considered in the computation of households impacted by potential AMTS stations.

Allen Davidson received his BSEE from the University of Illinois in Urbana Illinois in 1964 and his MSEE from Drexel University in Philadelphia, Pa. in 1970.

He started work in the field of antennas as a student at the University of Illinois Antenna Lab in 1962. He then spent 4 years at the RCA Broadcast TV Antenna Center in New Jersey and 3 1/2 years at Magnavox in Urbana Illinois working on specialized antennas before coming to Motorola in 1971.

He worked on communications antennas and radio systems at Motorola for 27 years, building the first MicroTAC Cellular portable radio antenna in the early 1970's. He spent several years establishing limitations on the use of adaptive antennas in the land mobile radio environment. One of his latest assignments was in Japan where he assisted in the writing of the standard for the new generation of digital mobile radios at 1.5 GHz and the field test that verified the performance of this new technology. Throughout this time, Mr. Davidson has done research into base, mobile, and portable land mobile antennas, multipath propagation, and system design in the terrestrial and mobile satellite services.

He is now semi-retired while continuing in the field of antennas and communications systems through Davidson Consulting Engineering. He is presently making long term (multi-year) UHF propagation measurements.

He has published 34 technical papers in the field of antennas and communications systems, and received the best paper of the year award for the VTS Transactions in 1975. He has been granted 16 US Government patents.

He was elected to Pi Mu Epsilon, the honorary Mathematics fraternity and Sigma Tau, the honorary Engineering fraternity. He is a member of the IEEE APS and VTS, the Bioelectromagnetics Society, the TIA standards subcommittees TR-8.11 on Land Mobile Antennas, TR-8.8 on RF systems, and TR-8.17 on RF Exposure. He was elected to the Motorola Science Advisory Board Associates and was a Dan Noble Fellow (the highest technical award granted by Motorola)

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